

## UTILITY PATENT APPLICATION TRANSMITTAL

Attorney Docket No.: 12969

First Named Inventor/Identifier: Bitler

To the Assistant Commissioner for Patents

Transmitted herewith for filing under 35 USC §111 and 37 CFR §1.53(b) is a non-provisional utility patent application entitled: **Polymeric Thickeners for Oil-containing Compositions**

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**Items or Papers Included**

Title page

Specification (Description: 11 pages; Claims: 2 page(s); Abstract: 1 page)

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POLYMERIC THICKENERS FOR OIL-CONTAINING COMPOSITIONS

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## BACKGROUND OF THE INVENTION

### Field of the Invention

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This invention relates to polymeric thickeners for oil-containing compositions.

### Introduction to the Invention

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It is known to use polymers to thicken oil-containing compositions. Reference may be made for example to U.S. Patent No. 5,318,995 (Mondet et al) and U.S. Patent No. 5,736,125 (Morawsky et al), the disclosure of each of which is incorporated herein by reference for all purposes.

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In U.S. Patent No. 5,736,125, the thickener is a copolymer containing (a) units containing a hydrophobic moiety, in particular an alkyl group containing 10 to 22 carbon atoms, a fluorinated alkyl group containing at least 6 carbon atoms, styrene, or an alkyl-substituted styrene in which the alkyl group contains 1 to 24 carbon atoms, and (b) units containing a hydrophilic moiety which is a carboxylic group, a dicarboxylic group, or a monoester or a monoamide of a dicarboxylic group, the units being derived from an alpha-beta ethylenically unsaturated carboxylic mono- or di-acid. No reference is made to the presence of other units. The copolymer has an acidity from about 0.1 to about 4.0 meq/g. The copolymers are for example copolymers of a long chain alkyl acrylate, and acrylic or methacrylic acid.

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In U.S. Patent No. 5,318, 995, the thickener is a copolymer which is defined as containing (a) 90 to 99% of units which have a first specified formula and which contain, in a side chain, a linear or branched hydrocarbon chain containing 4 to 22 carbon atoms, and (b) units which make up the remainder of the copolymer and which have a second specified formula containing, in a side chain, a carboxylic or sulfonic acid group which is at least partially present in the form of a salt. The copolymers are for example copolymers which consist of units derived from (a) an alkyl acrylate, methacrylate, acrylamide or methacrylamide, and (b) an acrylamido compound containing a carboxylic or sulfonic acid group, the copolymer having been treated with a suitable salt-forming compound to salify the carboxylic or sulfonic acid groups. The presence of other units is excluded by the definition.

Further disclosure of the thickened oil-containing compositions is to be found in U.S. Patent Nos. 4,720,303, 4,737,541, 4,794,139, 4,839,166, 4,939,179, 4,971,722, 5,053,257, 5,086,142, 5,112,601, 5,192,462, 5,247,121, 5,256,737, 5,2700,379, 5,319, 5 255, 5,415:790, 5,422,233, 5,442, 054, 5,516,544, 5,530,045, and 5,6100,202. The entire disclosure of each of those United States patents is incorporated herein by reference for all purposes.

### SUMMARY OF THE INVENTION

10 I have discovered, in accordance with the present invention, that oil-containing compositions can be thickened with polymers which contain long chain alkyl groups in side chains but which contain no, or relatively few, acid groups as specified in U.S. Patent No. 5,736,125 or acid salt groups as specified in U.S. Patent No. 5,318,995. 15 Furthermore, I have been able to obtain improved results through the use of such polymers. The polymers which are useful in the present invention are crystalline polymers, preferably side chain crystalline (SCC) polymers, which have a crystalline melting point,  $T_p$ , and an onset of melting temperature,  $T_o$ , such that  $T_p - T_o$  is less than  $T_p^{0.7}$ ; and which are soluble in the oil at temperatures above  $T_p$ . They must be 20 dispersed in the oil by a process which comprises (i) dissolving the polymer in the oil at a temperature above  $T_p$ , and (ii) cooling the solution to crystallize the polymer in the oil. The polymer generally has at least one of (i.e. may have two or more of) the following characteristics which distinguish it from the SCC polymers previously disclosed as thickeners for oil containing compositions:

- 25 (i) it is a side chain crystalline (SCC) polymer which contains repeating units containing at least one group selected from oxygen-containing groups, e.g. a hydroxyl group; nitrogen-containing groups, e.g. N-alkyl amine, tertiary amine and pyrrolidinone groups; fluorine-containing groups; and silicon-containing groups, e.g. silyl groups;
- 30 (ii) it is a side chain crystalline (SCC) polymer which is substantially free of carboxylic groups, carboxylic groups in the form of salts, and sulfonic acid groups in the form of salts;

- (iii) it is a side chain crystalline (SCC) polymer which contains carboxylic acid groups in an amount less than 0.075 meq/g;
- (iv) it is a side chain crystalline (SCC) polymer which contains repeating units containing long chain alkyl groups containing at least 26 carbon atoms;
- 5 (v) it is a side chain crystalline (SCC) polymer which is substantially free of functional groups;
- (vi) it is a side chain crystalline (SCC) polymer which is substantially free of ionized and ionizable groups;
- 10 (vii) it is a side chain crystalline (SCC) polymer which is a block copolymer or a graft copolymer;
- (viii) it is a side chain crystalline (SCC) polymer which is a homopolymer;
- (ix) it is a main chain crystalline polymer; and
- (x) it is a homopolymer or copolymer of caprolactone.

15 The composition must be maintained at a temperature below  $T_p$ , since the polymer will cease to have a thickening effect if it redissolves in the oil. The composition can be free of water, or can be a water-in-oil emulsion.

20 One of the advantages which results from the use of such polymers as thickening agents is that they reduce or remove the need to use surface active agents in water-in-oil emulsions. This is particularly useful in personal care products, since it is conventional for such products to contain surfactants which can cause an adverse reaction when they contact human skin. I believe that this advantage will be observed with the known thickeners described in U.S. Patent No. 5,736,125, but not with those described in U.S. Patent No. 5,318,995. U.S. Patent No. 5,736,125 does not discuss

25 the conventional use of surfactants, but it does contain a single specific Example, Example 3, in which no surfactant is used. In that Example, the oil is a silicone oil, and the SCC polymer contains units derived from methacrylic acid. The present invention also provides, therefore, a water-in -oil emulsion which is different from that disclosed in example 3 of U.S. Patent No. 5,736,125 and which comprises

- 30 (1) an oil,

(2) dispersed in the oil, a polymer, preferably a side chain crystalline (SCC) polymer, which

(a) has a crystalline melting point,  $T_p$ , and an onset of melting temperature,  $T_o$ , such that  $T_p - T_o$  is less than  $T_p^{0.7}$ ;

(b) is soluble in the oil at temperatures above  $T_p$ , and

(c) has been dispersed in the oil by a process which comprises (i) dissolving the SCC polymer in the oil at a temperature above  $T_p$ , and (ii) cooling the solution from step (i) to crystallize the SCC polymer in the oil; and

(3) emulsified in the oil, water;

the composition being at a temperature below  $T_p$ ; and being substantially free from surfactants. Preferred compositions differ from the composition disclosed in Example 3 of U.S. Patent No. 5,736,125, in that they have one or both of the following characteristics

(a) the oil is not a silicone oil;

(b) the SCC polymer is free from units derived from methacrylic acid.

## DETAILED DESCRIPTION OF THE INVENTION

### Definitions and Abbreviations

In this specification, parts and percentages are by weight. Temperatures are in °C. The onset of melting,  $T_o$ , the peak melting temperature,  $T_p$ , and the heat of fusion, J/g, are determined using a DSC calorimeter (at a rate of temperature change of 10°C/min, typically from -10 to 150 °C., and on the second heat cycle). The abbreviations  $M_n$  and  $M_w$  are used to denote number average and weight average molecular weight in daltons, respectively, measured in tetrahydrofuran using size exclusion chromatography, configured with a Wyatt laser light scattering detector. Bulk viscosities given in the Examples for the polymeric thickeners are in centipoise and were measured using a Brookfield LVT viscometer with an electrically thermostatted Thermosel heater, controlled for example to 95 °C., and small sample adapter using spindles 4 and 7. The procedure used in the Examples to compare the effectiveness of

the polymeric thickeners was as follows. 5 parts of the thickener were dissolved in 95 parts of hydrogenated polyisobutylene (HPIB) with stirring at 120 °C (HPIB is a light oil). The resulting solution was placed in an incubator at 20 °C. for 16 hours. The viscosity of cooled product in centipoise was determined using a Brookfield DV-I+ digital

viscometer with CP-51 spindle using a sample adapter which was thermostatically controlled, for example, to 25 °C. The viscosities were measured after four minutes at a speed of 2.5 rpm, i.e. after 10 revolutions. The abbreviation CxA is used to denote an n-alkyl acrylate in which the n-alkyl group contains x carbon atoms, the abbreviation Cx alkyl is used to denote an n-alkyl group which contains x carbon atoms, and the abbreviation CxM is used to denote an n-alkyl methacrylate in which the n-alkyl group contains x carbon atoms. Other abbreviations are given elsewhere in the specification.

### The Polymeric Thickeners

The polymers used as thickeners in the present invention are crystalline, this term being used to include polymers containing a crystalline polymeric moiety which is chemically bound to a non-crystalline moiety. The thickener can be a single polymer or a mixture of polymers, and the polymer can be a homopolymer, or a copolymer of two or more comonomers, including random copolymers, graft copolymers, block copolymers and thermoplastic elastomers. Preferably at least part of the polymer is a side chain crystallizable (SCC) polymer. The SCC polymer may for example be derived from one or more acrylic, methacrylic, olefinic, epoxy, vinyl, ester-containing, amide-containing or ether-containing monomers. The molecular weight of an SCC polymer is relatively unimportant to its  $T_p$ , but is generally an important factor in determining the  $T_p$  of other polymers. The preferred SCC polymers are described in detail below.

However, the invention includes the use of other crystalline polymers having the desired properties. Such other polymers include for example polymers in which the crystallinity results exclusively or predominantly from the polymer backbone, e.g. polymers of  $\alpha$ -olefins containing 2 to 12, preferably 2 to 8, carbon atoms, e.g. polymers of monomers having the formula  $CH_2 = CHR$ , where R is hydrogen, methyl, propyl, butyl, pentyl, 4-methylpentyl, hexyl or heptyl, as well as other polymers such as polyesters, polyamides,

for example homopolymers and copolymers of caprolactone, and polyalkylene oxides, for example polytetrahydrofuran.

It is important that the polymer should melt over a relatively small temperature range. The closer  $T_p$  is to room temperature, the more rapid the transition should preferably be. Thus  $T_p - T_o$  is less than  $T_p^{0.7}$ , particularly less than  $T_p^{0.6}$ ,  $T_o$  and  $T_p$  being in °C.  $T_p$  can vary widely, depending on the conditions under which the composition is to be used, as further discussed below.  $T_p - T_o$  is preferably less than 10°C, particularly less than 6°C.

The SCC polymers used in the present invention are in themselves well known. Publications describing SCC polymers include U.S. Patent Nos. 4,830,855, 5,120,349, 5,156,911, 5,387,450, 5,412,035, 5,665,822, 5,783,302, 5,752,926, 5,807,291, 5,469,867, and 5,826,584; J. Poly. Sci. 60, 19 (1962), J. Poly. Sci. (Polymer Chemistry) 7, 3053 (1969), 9, 1835, 3349, 3351, 3367, 10, 1657, 3347, 18, 2197, 19, 1871, J. Poly. Sci., Poly-Physics Ed 18 2197 (1980), J. Poly. Sci., Macromol. Rev, 8, 117 (1974), Macromolecules 12, 94 (1979), 13, 12, 15, 18, 2141, 19, 611, JACS 75, 3326 (1953), 76; 6280, Polymer J 17, 991 (1985); and Poly. Sci USSR 21, 241 (1979). The disclosure of each of those U.S. patents and publications is incorporated herein by reference for all purposes.

The SCC polymer preferably used in this invention can be a homopolymer, or a copolymer of two or more comonomers, including random copolymers, graft copolymers, block copolymers and thermoplastic elastomers. The number average molecular weight of the SCC polymer is generally from 10,000 to 1,500,000, preferably 12,000 to 1,000,000.

Preferred SCC polymers comprise side chains comprising linear polymethylene moieties containing 10 to 50, especially 14 to 22, carbon atoms, or linear perfluorinated or substantially perfluorinated polymethylene moieties containing 6 to 50 carbon atoms. Polymers containing such side chains can be prepared by polymerizing one or more corresponding linear aliphatic acrylates or methacrylates, or equivalent monomers such as acrylamides or methacrylamides. A number of such monomers are available commercially, either as individual monomers or as mixtures of identified monomers, for



example C12A, C14A, C16A, C18A, C22A, a mixture of C18A, C20A and C22A, a mixture of C26A to C40A, fluorinated C8A (AE800 from American Hoechst) and a mixture of fluorinated C8A, C10A and C12A (AE12 from American Hoechst). Generally the polymers also contain units derived from one or more other comonomers containing desired functional groups, for example the monomers listed below and equivalent monomers such as acrylamides and methacrylamides. In the list below, the term (meth) acrylate means that the compound may be either an acrylate or a methacrylate.

(a) Nitrogen-containing monomers, for example N,N-dialkyl amino (in particular, dimethylamino) (meth)acrylates; ammonium salt containing the (meth) acrylates, for example 2-trimethylammonium methylmethacrylate chloride, methacrylamidopropyl trimethylammonium chloride, N,N-(diethyl or dimethyl)aminoethyl(meth)acrylate methosulfate; N-vinylpyrrolidinone; imides like the ring-closed reaction products of maleic or itaconic anhydride with primary amines; 2-methacryloxy-N-ethylmorpholine; n or t-butylacrylamide; (meth)acrylamide; dimethylaminopropyl methacrylamide; 2-t-butylaminoethyl methacrylate; (meth)acrylonitrile; t-butylaminoethyl (meth)acrylate; acryloylmorpholine; N-(2-hydroxyethyl)acetamide and 1-piperidinoethyl (meth)acrylate.

(b) Oxygen-containing monomers, for example hydroxyalkyl (in particular, hydroxyethyl, hydroxypropyl, and hydroxybutyl) (meth)acrylates; tetrahydrofurfuryl (meth)acrylate; glycidyl methacrylate; alkoxyalkyl (meth)acrylate, e.g. methoxyethyl (meth)acrylate; 1-acryloxy-2-hydroxy-3-phenoxypropane; methylol methacrylate; ethoxyethyl (meth)acrylate; 2-(2-ethoxyethoxy)ethylacrylate; acetoacetoxyethyl (meth)acrylate; phenoxyethyl (meth)acrylate and (meth)acrolein.

(c) Fluorine-containing monomers, for example trifluoroethyl (meth)acrylate, heptafluorodecyl (meth)acrylate, octafluoropentyl (meth)acrylate, eicosafuoroundecyl (meth)acrylate, hexadecafluorononyl (meth)acrylate, and tetrahydroperfluorodecyl (meth)acrylate.

(d) Silicon-containing , e.g. silyl, monomers, for example trimethylsiloxy ethyl(meth)acrylate, 3-acryloxypropyl trimethoxysilane, and 3-acryloxypropyl tris(trimethylsiloxy)silane.

When the SCC polymer is a graft or block copolymer, it can be formed either by copolymerizing a vinyl type macromonomer with other monomers, or by making an SCC polymer, and then reacting the functionalized polymer with the second block material, for example a urethane or epoxy block, polyethyleneoxide or polypropyleneoxide or polytetramethyleneoxide and the like polyether blocks, polysiloxane or poly(alkyl or alkoxy)silane blocks.

The SCC polymer should contain sufficient long chain groups that it will dissolve in the oil at the temperature above  $T_p$ . When the SCC polymer is used to thicken and oil, or mixture of oils, which is free from water, it generally contains at least 50 %, preferably at least 60%, particularly at least 80%, of units derived from a long chain monomer, and can contain up to 100% of such units. When the SCC polymer is used to thicken a water in oil emulsion, it will generally contain at least 5%, preferably at least 10%, of units derived from a monomer containing a functional group, and may contain higher amounts, provided that the SCC polymer will dissolve in the oil.

The molecular weight of the thickening polymer should be sufficiently high that the polymer, after it has been dissolved in the oil, will precipitate from the oil when the heated mixture is cooled, for example to a temperature at least 10-20 °C. below  $T_p$ , thus producing an opaque mixture. This is believed to result in the formation of a polymer network in which the polymer crystallites are connected to one another by semisoluble chains.

The  $T_p$  of the thickening polymer is preferably 10-40 °C., particularly 10-30 °C., especially about 20 °C., above the temperature at which the composition is to be used.

It appears that the oil plasticizes the thickening polymer, so that its melting point in the composition is for example 5-10 °C. lower than  $T_p$ , and it is therefore important that  $T_p$  is sufficiently above the temperature of use to ensure that the thickening polymer does not melt during use. Thus for compositions to be used at 20-25 °C. the thickening polymer preferably has a  $T_p$  of above 40 °C., preferably 40-50 °C. If the  $T_p$  of the thickening polymer is too far above the temperature of use, this can result in excessive precipitation of the polymer and a reduction in the thickening effect. It is preferred, therefore, that  $T_p$  is not more than 30 °C., preferably not more than 20 °C., above the temperature of use. Depending on the expected temperature of use,  $T_p$  may be from 0-150 °C. generally 10-100 °C. for example 20-80 °C.

The amount of the polymeric thickener preferably used varies with the application. It is usually unnecessary to use more than 10% of the total composition, and smaller amounts such as 3 to 7%, for example about 5%, are often effective.

### Oils

The new polymeric thickeners are effective with a broad range of oils. Suitable oils are disclosed, for example, at column three, line 37, to column 4, line 4, of U.S. Patent No. 5,736,125, and elsewhere in the documents incorporated by reference herein.

### Compositions

The new polymeric thickeners are useful for thickening a wide variety of compositions. The compositions can be free from water, or can be water-in-oil emulsions. The invention is particularly useful for personal care compositions, for example cosmetics, toiletries, and cleansers, including but not limited to lipsticks, deodorant sticks, nail varnishes, creams and gels and oils including sun creams, protective hand creams, night renewal creams, body milks and lotions, light facial cream, protective day cream, liquid moisturizing emulsions, oil-in-water creams, water-in-oil creams, and the like and well as thickened oil products with or without water as well as those designed to assist in removing other cosmetic, makeup or personal care products. However, the invention is also useful in other contexts, for example in paints,

film forming compositions, inks, and compositions carrying active ingredients such as UV absorbers, fragrances, biocides, antimicrobial agents, germicides, antioxidants, preservatives, disinfectants, enzymes, nutrients, minerals, and drugs (including pharmaceuticals which are active physiologically or pharmacologically, either topically or systemically) as well as other uses disclosed in the documents incorporated by reference. Compositions containing a thickener containing an ammonium salt are likely to be useful in certain types of hair care compositions.

The invention is illustrated by the following Examples, some of which are comparative examples.

### Examples

Polymers and copolymers were made using the ingredients and amounts thereof shown in the Table below, using the following generalized method. To a resin kettle equipped with overhead stirrer and condenser was added 20% of the monomers and chain transfer agents. The mixture in the resin kettle was heated to 110 °C., and oxygen was removed from the system through nitrogen purge for about 30 min followed by addition of 20% of the starting initiator charge. After allowing sufficient time for any initial exotherm to abate, the remaining monomers, chain transfer agents and starting initiator were pumped into the reaction vessel over 60-90 min. The polymer mixture was allowed to continue reacting for 60 min followed by addition of the chase initiator and reaction for 60 min. The mixture was put under reduced pressure for 60 min to removal volatile residuals. The resulting polymers were generally yellow to white solids. The molecular weight,  $T_p$ , and viscosity of each sample was measured. The effectiveness of the polymers as thickeners for HPIB was measured as described above, and the results are shown in the Table below. The following abbreviations are used in the Table. ME = mercaptoethanol; MA = methacrylic acid; NVP = N-vinylpyrrolidinone;DMAEA = N,N-dimethylaminoethyl acrylate; HEA = 2-hydroxyethyl acrylate; TAPO = t-amylperoxy 2-ethylhexanoate sold by Witco as Esperox 570P, 75% active in liquid; TBPB = t-butylperoxybenzoate sold by Witco as Esperox 10; and opq = opaque in appearance.

TABLE

Example	1	2*	3	4*	5	6	7	8
C16A				95				
C18A	80		95		100	85	85	85
C22A		95						
HEA	20							
NVP						15	15	
DMAEA								15
MA		5	5	5				
ME	0.34	0.17	0.17	0.17	0.17	0.34	0.34	0.1
TAPO	1.73	1.73	1.73	1.73	1.73	1.73	1.73	1.73
TAPB	0.67	0.67				0.67	0.67	
TBPB			0.5	0.5	0.5			0.5
Tp °C.	48	67	47	39	50	48	46	45
J/g	56	99	57	64	73	29	61	60
Mw	236K		427K	1,000K	950K			
Mn	52K		240K	520K	230K			
Bulk viscosity	4,000	2,500	19,000	24,000	2,000	3,950	4,000	350
Visc in HPIB	12,600 opq	164 opq	2600 opq	<50 clear	5400 opq	5100 opq	6200 opq	6000 opq

\* denotes comparative example.

What is claimed is

1. A thickened oil composition comprising

- (1) an oil, and
- (2) dispersed in the oil, a polymer which
  - (a) has a crystalline melting point,  $T_p$ , and an onset of melting temperature,  $T_o$ , such that  $T_p - T_o$  is less than  $T_p^{0.7}$ ;
  - (b) is soluble in the oil at temperatures above  $T_p$ ,
  - (c) has been dispersed in the oil by a process which comprises
    - (i) dissolving the polymer in the oil at a temperature above  $T_p$ , and
    - (ii) cooling the solution to crystallize the polymer in the oil, and
  - (d) has at least one of the following characteristics
    - (i) it is a side chain crystalline (SCC) polymer which contains repeating units containing at least one group selected from oxygen-containing groups, e.g. a hydroxyl group; nitrogen-containing groups; fluorine-containing groups; and silicon-containing groups, e.g. silyl groups;
    - (ii) it is a side chain crystalline (SCC) polymer which is substantially free of carboxylic groups, carboxylic groups in the form of salts, and sulfonic acid groups in the form of salts;
    - (iii) it is a side chain crystalline (SCC) polymer which contains carboxylic acid groups in an amount less than 0.075 meq/g;
    - (iv) it is a side chain crystalline (SCC) polymer which contains repeating units containing long chain alkyl groups containing at least 26 carbon atoms;

- (v) it is a side chain crystalline (SCC) polymer which is substantially free of functional groups;
- (vi) it is a side chain crystalline (SCC) polymer which is substantially free of ionizable groups;
- (vii) it is a side chain crystalline (SCC) polymer which is a block copolymer or a graft copolymer;
- (viii) it is a homopolymer;
- (xi) it is a main chain crystalline polymer; and
- (xii) it is a homopolymer or copolymer of caprolactone;

the composition being at a temperature below  $T_p$ .

2. A composition according to Claim 1 which is substantially free of water.

3. A composition according to Claim 1 which is a water-in-oil emulsion.

4. A water-in -oil emulsion comprising

(1) an oil,

(2) dispersed in the oil, a polymer which

(a) has a crystalline melting point,  $T_p$ , and an onset of melting temperature,  $T_o$ , such that  $T_p - T_o$  is less than  $T_p^{0.7}$ ;

(b) is soluble in the oil at temperatures above  $T_p$ , and

(c) has been dispersed in the oil by a process which comprises  
(i) dissolving the polymer in the oil at a temperature above  $T_p$ ,  
and

(ii) cooling the solution from step (i) to crystallize the polymer in the oil; and

(3) emulsified in the oil, water;

the composition being at a temperature below  $T_p$ ; being substantially free from surfactants; and having at least one of the following characteristics

(a) the oil is not a silicone oil;

(b) the polymer is free from units derived from methacrylic acid.

### ABSTRACT

- Novel thickeners for oil-containing compositions are crystalline polymers, preferably side chain crystalline polymers, which (a) have a crystalline melting point,  $T_p$ , and an onset of melting temperature,  $T_o$ , such that  $T_p - T_o$  is less than  $T_p^{0.7}$ ; (b) are soluble in the oil at temperatures above  $T_p$ , and (c) have been dispersed in the oil by a process which comprises (i) dissolving the polymer in the oil at a temperature above  $T_p$ , and (ii) cooling the solution from step (i) to crystallize the polymer in the oil;
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